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$$\frac{2r^3}{\alpha\beta\gamma}+\left(\frac{1}{\alpha^2}+\frac{1}{\beta^2}+\frac{1}{\gamma^2}\right)r^2=1, \text{ or } r^3+\tfrac{1}{2}\left(\frac{\alpha\beta}{\delta}+\frac{\beta\gamma}{\alpha}+\frac{\gamma\alpha}{\beta}\right)r^2=\tfrac{1}{2}\alpha\beta\gamma.$$

Example. Let $\alpha=275$, $\beta=325$, $\gamma=429$; then $r^3+539\frac{1}{6}r^2-19170937\frac{1}{2}=0$; whence $(r-165)(r^2+704\frac{1}{6}r+116187\frac{1}{2})=0$.

$\therefore r=165$. Also, $r=-137.97+$ and $r=842.13+$.

CALCULUS.

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140. Proposed by C. C. BEBOUT, Professor of Mathematics, Elgin High School, Elgin, Ill.

A pole two inches in diameter is set vertically in a level plat of ground. At a point ten feet from the ground a string is attached. A man holds the other end of the string and walks about the pole keeping the string stretched taut, and his hand at a constant distance of four feet from the ground, till the string is all wound upon the pole. If string is ten feet long, how far has his hand moved in the operation?

Solution by G. B. M. ZERR, A.M., Ph. D., Professor of Chemistry and Physics, The Temple College, Philadelphia, Pa.

Let n be the number of times the string 10 feet feet in length will encircle the cylinder in a height of 6 feet. Circumference of cylinder$=\frac{1}{6}\pi$ feet, $x=$distance between successive portions of the string on the same generating line.

Then $\sqrt{[(\frac{1}{6}\pi)^2+x^2]}=10/n$ also $nx=6$.

$$\therefore n\sqrt{\left(\frac{\pi}{6}\right)^2+\left(\frac{6}{n}\right)^2}=10 \text{ or } \frac{\pi^2n^2}{36}=64. \quad \therefore n=\frac{48}{\pi},\ x=\tfrac{1}{8}\pi.$$

The distance moved by the hand is given on page 319, No. 9, Vol. I, of the MONTHLY, and is there worked out in full. It is $s=2\pi^2r^2m^2$ where r is the radius of the cylinder and m is the number of times the string is wound around the cylinder or the same as the value of n above. $r=\frac{1}{12}$ feet, $m=n=48/\pi$.

$\therefore s=32$ feet.

Also solved by *T. T. DAVIS*.

141. Proposed by B. F. FINKEL, A.M.. M.Sc.. Professor of Mathematics and Physics, Drury College, Springfield, Mo.

The curve $r^n=a^n\sin n\theta$ rolls along a straight line. Show that the intrinsic equation to the evolute of the locus of the pole is $s^n=a^m[1+1/n]^n\sin\psi$. [Edward's *Differential Calculas*, page 502.

Solution by WILLIAM HOOVER, A. M.. Ph. D., Professor of Mathematics and Astronomy, Ohio University, Athens, Ohio.

The distance from the point of tangency to the pole is normal to the path of the pole. Let this distance, which is a radius vector of the rolling curve, be r, and the perpendicular from the pole upon the fixed line be p.

Taking the fixed line as the axis of x, p is an ordinate of the pole, and r is the length of normal and is expressed by

$$y\sqrt{1+\frac{dy^2}{dx^2}}.$$

Now, all curves of the form $r^m=a^m\cos m\theta$ have their pedal equations in the form $r^{m+1}=a^mp....[a]$.

It is plain that the given curve may be so expressed. The equation $[a]$ then gives for the differential equation of the locus of the pole

$$\left(y\sqrt{1+\frac{dy^2}{dx^2}}\right)^{n+1}=a^ny,\text{ or, }\frac{dy}{dx}=\sqrt{}[a^{2n/(n+1)}-y^{2n/(n+1)}\div y^{n/(n+1)},$$

in which $dy/dx=\cot\phi$ from the form of the given curve.

Then $y=a\sin^{(n+1)/n}\phi$, $\dfrac{dy}{d\phi}=\dfrac{n+1}{n}a\sin^{1/n}\phi\cos\phi....[b]$.

Also, $\dfrac{dx}{dy}=\tan\phi$, $\dfrac{ds}{dy}=\dfrac{1}{\cos\phi}$; then $\dfrac{ds}{d\phi}=\dfrac{n+1}{n}a\sin^{1/n}\phi....[c]$.

But this gives the radius of curvature in the locus of the pole, which again is the length of arc corresponding in the evolute, which vanishes with ϕ.

$\therefore$ the evolute is $s=\dfrac{n+1}{n}a\sin^{1/n}\phi$, as required.

Also solved by *G. B. M. ZERR.*

142. Proposed by J. SCHEFFER, A. M., Hagerstown, Md.

Solve the differential equation,

$$[a-x]\frac{dz}{dx}+[b-y]\frac{dz}{dy}=c-z.$$

Solution by G. B. M. ZERR, A. M., Ph. D., The Temple College, Philadelphia, Pa.; WILLIAM HOOVER, A.M., Ph. D., Ohio University, Athens, O.; and the PROPOSER.

Putting, as usual, $dz/dx=p$, $dz/dy=q$, and then comparing the given equation with $Pp+Qq=R$, we have $P=a-x$, $Q=b-y$, $R=c-z$.

Then, $\dfrac{dx}{P}=\dfrac{dz}{R}$ gives $\dfrac{dx}{x-a}=\dfrac{dz}{z-c}$, and

$$\frac{dy}{Q}=\frac{dz}{R}\text{ gives }\frac{dy}{y-b}=\frac{dz}{z-c}.$$

These equations give $\dfrac{x-a}{z-c}=\alpha$, $\dfrac{y-b}{z-c}=\beta$; so that the solution is

$$\frac{b-y}{c-z}=\phi\left(\frac{a-x}{c-z}\right).$$

Solved similarly by *LON C. WALKER.*